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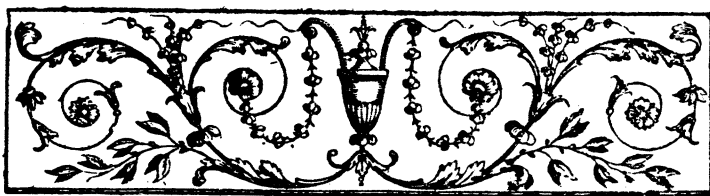
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TRANSACTIONS
OF THE
American PHILOSOPHICAL SOCIETY, &c.

N° I.

*A Letter from Dr. B. FRANKLIN to Dr. INGENHAUSZ,
Physician to the Emperor, at Vienna.*

Dear Friend,

At sea, August 28th, 1785.

Read 21st
Oct. 1785.

IN one of your letters, a little before I left France, you desire me to give you in writing my thoughts upon the construction and use of chimneys, a subject you had sometimes heard me touch upon in conversation. I embrace willingly this leisure afforded by my present situation to comply with your request, as it will not only show my regard to the desires of a friend, but may at the same time be of some utility to others; the doctrine of chimneys appearing not to be as yet generally well understood, and mistakes respecting them being attended with constant inconvenience, if not remedied; and with fruitless expence, if the true remedies are mistaken.

Those who would be acquainted with this subject should begin by considering on what principle smoke ascends in any chimney. At first many are apt to think that smoke
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is in its nature and of itself specifically lighter than air, and rises in it for the same reason that cork rises in water. These see no cause why smoke should not rise in the chimney, though the room be ever so close. Others think there is a power in chimneys to *draw* up the smoke, and that there are different forms of chimneys which afford more or less of this power. These amuse themselves with searching for the best form. The equal dimensions of a funnel in its whole length is not thought artificial enough, and it is made, for fancied reasons, sometimes tapering and narrowing from below upwards, and sometimes the contrary, &c. &c. A simple experiment or two may serve to give more correct ideas. Having lit a pipe of tobacco, plunge the stem to the bottom of a decanter half filled with cold water; then putting a rag over the bowl, blow through it and make the smoke descend in the stem of the pipe, from the end of which it will rise in bubbles through the water; and being thus cooled, will not afterwards rise to go out through the neck of the decanter, but remain spreading itself and resting on the surface of the water. This shows that smoke is really heavier than air, and that it is carried upwards only when attached to, or acted upon, by air that is heated, and thereby rarefied and rendered specifically lighter than the air in its neighbourhood.

Smoke being rarely seen but in company with heated air, and its upward motion being visible, though that of the rarefied air that drives it is not so, has naturally given rise to the error.

I need not explain to you, my learned friend, what is meant by rarefied air; but if you make the public use you propose of this letter, it may fall into the hands of some who are unacquainted with the term and with the thing. These then may be told, that air is a fluid which has weight as well as others, though about eight hundred times lighter than water. That heat makes the particles of air
recede

recede from each other and take up more space, so that the same weight of air heated will have more bulk, than equal weights of cold air which may surround it, and in that case must rise, being forced upwards by such colder and heavier air, which presses to get under it and take its place. That air is so rarefied or expanded by heat, may be proved to their comprehension by a lank blown bladder, which laid before a fire will soon swell, grow tight and burst.

Another experiment may be to take a glass tube about an inch in diameter, and twelve inches long, open at both ends and fixed upright on legs so that it need not be handled, for the hands might warm it. At the end of a quill fasten five or six inches of the finest light filament of silk, so that it may be held either above the upper end of the tube or under the lower end, your warm hand being at a distance by the length of the quill. If there were

Plate I.
Figure 1.

any motion of air through the tube, it would manifest itself by its effect on the silk; but if the tube and the air in it are of the same temperature with the surrounding air, there will be no such motion, whatever may be the form of the tube, whether crooked or straight, narrow below and widening upwards, or the contrary; the air in it will be quiescent. Warm the tube, and you will find as long as it continues warm, a constant current of air entering below and passing up through it, till discharged at the top; because the warmth of the tube being communicated to the air it contains, rarefies that air and makes it lighter than the air without, which therefore presses in below, forces it upwards, follows and takes its place, and is rarefied in its turn. And, without warming the tube, if you hold under it a knob of hot iron, the air thereby heated will rise and fill the tube, going out at its top, and this motion in the tube will continue as long as the knob remains hot, because the air entering the tube below is heated and rarefied by passing near and over that knob. That

That this motion is produced merely by the difference of specific gravity between the fluid within and that without the tube, and not by any fancied form of the tube itself, may appear by plunging it into water contained in a glass jar a foot deep, through which such motion might be seen. The water within and without the tube being of the same specific gravity, balance each other, and both remain at rest. But take out the tube, stop its bottom with a finger and fill it with olive oil, which is lighter than water, then stopping the top, place it as before, its lower end under water, its top a very little above. As long as you keep the bottom stoppt, the fluids remain at rest, but the moment it is unstoppt, the heavier enters below, forces up the lighter, and takes its place. And the motion then ceases, merely because the new fluid cannot be successively made lighter, as air may be by a warm tube.

In fact, no form of the funnel of a chimney has any share in its operation or effect respecting smoke, except its height. The longer the funnel, if erect, the greater its force when filled with heated and rarefied air, to *draw* in below and drive up the smoke, if one may, in compliance with custom, use the expression *draw*, when in fact it is the superior weight of the surrounding atmosphere that *presses* to enter the funnel below, and so *drives up* before it the smoke and warm air it meets with in its passage.

I have been the more particular in explaining these first principles, because, for want of clear ideas respecting them, much fruitless expence has been occasioned; not only single chimneys, but in some instances, within my knowledge, whole stacks having been pulled down and rebuilt with funnels of different forms, imagined more powerful in *drawing* smoke; but having still the same height and the same opening below, have performed no better than their predecessors.

What is it then which makes a *smoky chimney*, that is, a chimney which instead of conveying up all the smoke,
discharges

discharges a part of it into the room, offending the eyes and damaging the furniture?

The causes of this effect, which have fallen under my observation, amount to *nine*, differing from each other, and therefore requiring different remedies.

1. *Smoky chimneys in a new house, are such, frequently from mere want of air.* The workmanship of the rooms being all good, and just out of the workman's hand, the joints of the boards of the flooring, and of the pannels of wainscoting are all true and tight, the more so as the walls, perhaps not yet thoroughly dry, preserve a dampness in the air of the room which keeps the wood-work swelled and close. The doors and the sashes too, being worked with truth, shut with exactness, so that the room is as tight as a snuff-box, no passage being left open for air to enter, except the key-hole, and even that is sometimes covered by a little dropping shutter. Now if smoke cannot rise but as connected with rarefied air, and a column of such air, suppose it filling the funnel, cannot rise, unless other air be admitted to supply its place; and if, therefore, no current of air enter the opening of the chimney, there is nothing to prevent the smoke coming out into the room. If the motion upwards of the air in a chimney that is freely supplied, be observed by the rising of the smoke or a feather in it, and it be considered that in the time such feather takes in rising from the fire to the top of the chimney, a column of air equal to the content of the funnel must be discharged, and an equal quantity supplied from the room below, it will appear absolutely impossible that this operation should go on if the tight room is kept shut; for were there any force capable of drawing constantly so much air out of it, it must soon be exhausted like the receiver of an air pump, and no animal could live in it. Those therefore who stop every crevice in a room to prevent the admission of fresh air, and yet would have their chimney carry up the smoke, require inconsistencies, and

and expect impossibilities. Yet under this situation, I have seen the owner of a new house, in despair, and ready to sell it for much less than it cost, conceiving it uninhabitable, because not a chimney in any one of its rooms would carry off the smoke, unless a door or window were left open. Much expence has also been made, to alter and amend new chimneys which had really no fault; in one house particularly that I knew, of a nobleman in Westminster, that expence amounted to no less than three hundred pounds, *after* his house had been, as he thought, finished and all charges paid. And after all, several of the alterations were ineffectual, for want of understanding the true principles.

Remedies. When you find on trial, that opening the door or a window, enables the chimney to carry up all the smoke, you may be sure that want of air *from without*, was the cause of its smoking. I say *from without*, to guard you against a common mistake of those who may tell you, the room is large, contains abundance of air, sufficient to supply any chimney, and therefore it cannot be that the chimney wants air. These reasoners are ignorant, that the largeness of a room, if tight, is in this case of small importance, since it cannot part with a chimney full of its air without occasioning so much vacuum; which it requires a great force to effect, and could not be borne if effected.

It appearing plainly, then, that some of the outward air must be admitted, the question will be, how much is *absolutely necessary*; for you would avoid admitting more, as being contrary to one of your intentions in having a fire, viz. that of warming your room. To discover this quantity, shut the door gradually while a middling fire is burning, till you find that, before it is quite shut, the smoke begins to come out into the room, then open it a little till you perceive the smoke comes out no longer. There hold the door, and observe the width of the open crevice between
tween

tween the edge of the door and the rabbit it should shut into. Suppose the distance to be half an inch, and the door eight feet high, you find thence that your room requires an entrance for air equal in area to ninety six half inches, or forty eight square inches, or a passage of six inches by eight. This however is a large supposition, there being few chimneys, that, having a moderate opening and a tolerable height of funnel, will not be satisfied with such a crevice of a quarter of an inch; and I have found a square of six by six, or thirty six square inches, to be a pretty good medium, that will serve for most chimneys. High funnels with small and low openings, may indeed be supplied through a less space, because, for reasons that will appear hereafter, the *forcé of levity*, if one may so speak, being greater in such funnels, the cool air enters the room with greater velocity, and consequently more enters in the same time. This however has its limits, for experience shows that no increased velocity so occasioned, has made the admission of air through the key-hole equal in quantity to that through an open door; though through the door the current moves slowly, and through the key-hole with great rapidity.

It remains then to be considered how and where this necessary quantity of air from without is to be admitted so as to be least inconvenient. For, if at the door, left so much open, the air thence proceeds directly to the chimney, and in its way comes cold to your back and heels as you sit before your fire. If you keep the door shut, and raise a little the sash of your window, you feel the same inconvenience. Various have been the contrivances to avoid this, such as bringing in fresh air through pipes in the jams of the chimney, which pointing upwards should blow the smoke up the funnel; opening passages into the funnel above, to let in air for the same purpose. But these produce an effect contrary to that intended: For as it is the constant current of air passing from the room *through*
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the opening of the chimney into the funnel which prevents the smoke coming out into the room, if you supply the funnel by other means or in other ways with the air it wants, and especially if that air be cold, you diminish the force of that current, and the smoke in its efforts to enter the room finds less resistance.

The wanted air must then *indispensably* be admitted into the room, to supply what goes off through the opening of the chimney. M. Gauger, a very ingenious and intelligent French writer on the subject, proposes with judgment to admit it *above* the opening of the chimney; and to prevent inconvenience from its coldness, he directs its being made to pass in its entrance through winding cavities made behind the iron back and sides of the fireplace, and under the iron hearth-plate; in which cavities it will be warmed, and even heated, so as to contribute much, instead of cooling, to the warming of the room. This invention is excellent in itself, and may be used with advantage in building new houses; because the chimneys may then be so disposed, as to admit conveniently the cold air to enter such passages: But in houses built without such views, the chimneys are often so situated, as not to afford that convenience, without great and expensive alterations. Easy and cheap methods, though not quite so perfect in themselves, are of more general utility; and such are the following.

In all rooms where there is a fire, the body of air warmed and rarefied before the chimney is continually changing place, and making room for other air that is to be warmed in its turn. Part of it enters and goes up the chimney, and the rest rises and takes place near the ceiling. If the room be lofty, that warm air remains above our heads as long as it continues warm, and we are little benefited by it, because it does not descend till it is cooler. Few can imagine the difference of climate between the upper and lower parts of such a room, who have not tried it by the thermometer,

thermometer, or by going up a ladder till their heads are near the ceiling. It is then among this warm air that the wanted quantity of outward air is best admitted, with which being mixed, its coldness is abated, and its inconvenience diminished so as to become scarce observable. This may be easily done, by drawing down about an inch the upper sash of a window; or, if not moveable, by cutting such a crevice through its frame; in both which cases, it will be well to place a thin shelf of the length, to conceal the opening, and sloping upwards to direct the entering air horizontally along and under the ceiling. In some houses the air may be admitted by such a crevice made in the wainscot, cornish or plastering, near the ceiling and over the opening of the chimney. This, if practicable, is to be chosen, because the entering cold air will there meet with the warmest rising air from before the fire, and be soonest tempered by the mixture. The same kind of shelf should also be placed here. Another way, and not a very difficult one, is to take out an upper pane of glass in one of your sashes, set it in a tin frame, giving it two springing angular sides, and then replacing it, with hinges below on which it may be turned to open more or less above. It will then have the appearance of an internal sky light. By drawing this pane in, more or less, you may admit what air you find necessary. Its position will naturally throw that air up and along the ceiling. This is what is called in France a *Was ist das?* As this is a German question, the invention is probably of that nation, and takes its name from the frequent asking of that question when it first appeared. In England, some have of late years cut a round hole about five inches diameter in a pane of the sash and placed against it a circular plate of tin hung on an axis, and cut into vanes, which being separately bent a little obliquely, are acted upon by the entering air, so as to force the plate continually round like the vanes of a windmill. This ad-

Plate I.
Figure 2.

mits the outward air, and by the continual whirling of the vanes, does in some degree disperse it. The noise only, is a little inconvenient.

2. A second cause of the smoking of chimneys is, *their openings in the room being too large*; that is, too wide, too high or both. Architects in general have no other ideas of proportion in the opening of a chimney, than what relate to symmetry and beauty, respecting the dimensions of the room*; while its true proportion, respecting its function and utility depends on quite other principles; and they might as properly proportion the step in a staircase to the height of the story, instead of the natural elevation of men's legs in mounting. The proportion then to be regarded, is what relates to the height of the funnel. For as the funnels in the different stories of a house are necessarily of different heights or lengths, that from the lowest floor being the highest or longest, and those of the other floors shorter and shorter, till we come to those in the garrets, which are of course the shortest; and the force of draft being, as already said, in proportion to the height of funnel filled with rarefied air; and a current of air from the room into the chimney, sufficient to fill the opening, being necessary to oppose and prevent the smoke coming out into the room; it follows that the openings of the longest funnels may be larger, and that those of the shorter funnels should be smaller. For if there be a large opening to a chimney that does not draw strongly, the funnel may happen to be furnished with the air it demands by a partial current entering on one side of the opening, and leaving the other side free of any opposing current, may permit the smoke to issue there into the room. Much too of the force of draft in a funnel depends on the degree of rarefaction in the air it contains, and that depends on the nearness to the fire of its passage in entering the funnel. If it can enter far from the fire on each side, or far above the fire, in a wide or high opening, it receives little heat
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* See Appendix, N^o I.

in passing by the fire, and the contents of the funnel is by that means less different in levity from the surrounding atmosphere, and its force in drawing consequently weaker. Hence if too large an opening be given to chimneys in upper rooms, those rooms will be smoky: On the other hand, if too small openings be given to chimneys in the lower rooms, the entering air operating too directly and violently on the fire, and afterwards strengthening the draft as it ascends the funnel, will consume the fuel too rapidly.

Remedy. As different circumstances frequently mix themselves in these matters, it is difficult to give precise dimensions for the openings of all chimneys. Our fathers made them generally much too large; we have lessened them; but they are often still of greater dimension than they should be, the human eye not being easily reconciled to sudden and great changes. If you suspect that your chimney smokes from the too great dimension of its opening, contract it by placing moveable boards so as to lower and narrow it gradually, till you find the smoke no longer issues into the room. The proportion so found will be that which is proper for that chimney, and you may employ the bricklayer or mason to reduce it accordingly. However, as, in building new houses, something must be sometimes hazarded, I would make the openings in my lower rooms about thirty inches square and eighteen deep, and those in the upper, only eighteen inches square and not quite so deep; the intermediate ones diminishing in proportion as the height of funnel diminished. In the larger openings, billets of two feet long, or half the common length of cordwood, may be burnt conveniently; and for the smaller, such wood may be sawed into thirds. Where coals are the fuel, the grates will be proportioned to the openings. The same depth is nearly necessary to all, the funnels being all made of a size proper to admit a chimney-sweeper. If in large and elegant rooms custom or fancy should re-

quire the appearance of a larger chimney, it may be formed of expensive marginal decorations, in marble, &c. In time perhaps that which is fittest in the nature of things, may come to be thought handsomest. But at present when men and women in different countries show themselves dissatisfied with the forms God has given to their heads, waists and feet, and pretend to shape them more perfectly, it is hardly to be expected that they will be content always with the best form of a chimney. And there are some I know so bigotted to the fancy of a large noble opening, that rather than change it, they would submit to have damaged furniture, sore eyes and skins almost smoked to bacon.

3. Another cause of smoky chimneys is, *too short a funnel*. This happens necessarily in some cases, as where a chimney is required in a low building; for, if the funnel be raised high above the roof, in order to strengthen its draft, it is then in danger of being blown down, and crushing the roof in its fall.

Remedies. Contract the opening of the chimney, so as to oblige all the entering air to pass through or very near the fire; whereby it will be more heated and rarefied, the funnel itself be more warmed, and its contents have more of what may be called the force of levity, so as to rise strongly and maintain a good draft at the opening.

Or you may in some cases, to advantage, build additional stories over the low building, which will support a high funnel.

If the low building be used as a kitchen, and a contraction of the opening therefore inconvenient, a large one being necessary, at least when there are great dinners, for the free management of so many cooking utensils; in such case I would advise the building of two more funnels joining to the first, and having three moderate openings, one to each funnel, instead of one large one. When there is occasion to use but one, the other two may be kept shut
by

by sliding plates, hereafter to be described*; and two or all of them may be used together when wanted. This will indeed be an expence, but not an useless one, since your cooks will work with more comfort, see better than in a smoky kitchen what they are about, your victuals will be cleaner dressed and not taste of smoke, as is often the case; and to render the effect more certain, a stack of three funnels may be safely built higher above the roof than a single funnel.

The case of too short a funnel is more general than would be imagined, and often found where one would not expect it. For it is not uncommon, in ill-contrived buildings, instead of having a funnel for each room or fireplace, to bend and turn the funnel of an upper room so as to make it enter the side of another funnel that comes from below. By this means the upper room funnel is made short of course, since its length can only be reckoned from the place where it enters the lower room funnel; and that funnel is also shortened by all the distance between the entrance of the second funnel and the top of the stack: For all that part being readily supplied with air through the second funnel, adds no strength to the draft, especially as that air is cold when there is no fire in the second chimney. The only easy remedy here is, to keep the opening shut of that funnel in which there is no fire.

4. Another very common cause of the smoking of chimneys, is, *their overpowering one another*. For instance, if there be two chimneys in one large room, and you make fires in both of them, the doors and windows close shut, you will find that the greater and stronger fire shall overpower the weaker, and draw air down its funnel to supply its own demand; which air descending in the weaker funnel will drive down its smoke, and force it into the room. If, instead of being in one room, the two chimneys are in two different rooms, communicating by a door, the case is the same whenever that door is open. In a very tight

* See Appendix, N^o II.

tight house, I have known a kitchen chimney on the lowest floor, when it had a great fire in it, overpower any other chimney in the house, and draw air and smoke into its room, as often as the door was opened communicating with the staircase.

Remedy. Take care that every room have the means of supplying itself from without, with the air its chimney may require, so that no one of them may be obliged to borrow from another, nor under the necessity of lending. A variety of these means have been already described.

5. Another cause of smoking is, *when the tops of chimneys are commanded by higher buildings, or by a hill*, so that the wind blowing over such eminences falls like water over a dam, sometimes almost perpendicularly on the tops of the chimneys that lie in its way, and beats down the smoke contained in them.

Remedy. That commonly applied to this case, is a turncap made of tin or plate iron, covering the chimney above and on three sides, open on one side, turning on a spindle, and which being guided or governed by a vane, always presents its back to the current. This I believe may be generally effectual, though not certain, as there may be cases in which it will not succeed. Raising your funnels if practicable, so as their tops may be higher, or at least equal with the commanding eminence, is more to be depended on. But the turning cap, being easier and cheaper, should first be tried. If obliged to build in such a situation, I would chuse to place my doors on the side next the hill, and the backs of my chimneys on the furthest side; for then the column of air falling over the eminence, and of course pressing on that below and forcing it to enter the doors, or *Was-ist-dases* on that side, would tend to balance the pressure down the chimneys, and leave the funnels more free in the exercise of their functions.

6. There is another case of command, the reverse of that last mentioned. It is where the commanding eminence

nence is farther from the wind than the chimney commanded. To explain this a figure may be necessary. Suppose then a building whose side A, happens to be exposed to the wind, and forms a kind of dam against its progress. The air obstructed by this dam will like water press and search for passages through it; and finding the top of the chimney B, below the top of the dam, it will force itself down that funnel, in order to get through by some door or window open on the other side of the building. And if there be a fire in such chimney, its smoke is of course beat down, and fills the room.

Plate I.
Figure 3.

Remedy. I know of but one, which is to raise such funnel higher than the roof, supporting it, if necessary, by iron bars. For a turn-cap in this case has no effect, the dammed up air pressing down through it in whatever position the wind may have placed its opening.

I know a city in which many houses are rendered smoky by this operation. For their kitchens being built behind, and connected by a passage with the houses, and the tops of the kitchen chimneys lower than the top of the houses, the whole side of a street when the wind blows against its back, forms such a dam as above described; and the wind so obstructed forces down those kitchen chimneys, (especially when they have but weak fires in them) to pass through the passage and house, into the street. Kitchen chimneys so formed and situated, have another inconvenience. In summer, if you open your upper room windows for air, a light breeze blowing over your kitchen chimney towards the house, though not strong enough to force down its smoke as aforesaid, is sufficient to waft it into your windows, and fill the rooms with it; which, besides the disagreeableness, damages your furniture.

7. Chimneys, otherwise drawing well, are sometimes made to smoke by *the improper and inconvenient situation of a door*. When the door and chimney are on the same side of the room as in the figure, if the door A, being in the

Plate I.
Figure 4.

the corner is made to open against the wall, which is common, as being there, when open, more out of the way, it follows, that when the door is only opened in part, a current of air rushing in passes along the wall into and across the opening of the chimney B, and flirts some of the smoke out into the room. This happens more certainly when the door is shutting, for then the force of the current is augmented, and becomes very inconvenient to those who, warming themselves by the fire, happen to sit in its way.

The *Remedies* are obvious and easy. Either put an intervening screen from the wall round great part of the fireplace; or, which is perhaps preferable, shift the hinges of your door, so as it may open the other way, and when open throw the air along the other wall.

8. A room that has no fire in its chimney, is sometimes filled with *smoke which is received at the top of its funnel and descends into the room*. In a former paper* I have already explained the descending currents of air in cold funnels; it may not be amiss however to repeat here, that funnels without fires have an effect according to their degree of coldness or warmth, on the air that happens to be contained in them. The surrounding atmosphere is frequently changing its temperature; but stacks of funnels covered from winds and sun by the house that contains them, retain a more equal temperature. If, after a warm season, the outward air suddenly grows cold, the empty warm funnels begin to draw strongly upward; that is, they rarefy the air contained in them, which of course rises, cooler air enters below to supply its place, is rarefied in its turn and rises; and this operation continues, till the funnel grows cooler, or the outward air warmer, or both, when the motion ceases. On the other hand, if after a cold season, the outward air suddenly grows warm and of course lighter, the air contained in the cool funnels, being heavier, descends into the room; and the warmer

* See Appendix, N^o II.

warmer air which enters their tops being cooled in its turn, and made heavier, continues to descend; and this operation goes on, till the funnels are warmed by the passing of warm air through them, or the air itself grows cooler. When the temperature of the air and of the funnels is nearly equal, the difference of warmth in the air between day and night is sufficient to produce these currents, the air will begin to ascend the funnels as the cool of the evening comes on, and this current will continue till perhaps nine or ten o'clock the next morning, when it begins to hesitate; and as the heat of the day approaches, it sets downwards, and continues so till towards evening, when it again hesitates for some time, and then goes upwards constantly during the night, as before mentioned. Now when smoke issuing from the tops of neighbouring funnels passes over the tops of funnels which are at the time drawing downwards, as they often are in the middle part of the day, such smoke is of necessity drawn into these funnels, and descends with the air into the chamber.

The *Remedy* is to have a sliding plate, hereafter described*, that will shut perfectly the offending funnel.

9. Chimneys which generally draw well, do nevertheless sometimes give smoke into the rooms, *it being driven down by strong winds passing over the tops of their funnels*, though not descending from any commanding eminence. This case is most frequent where the funnel is short, and the opening turned from the wind. It is the more grievous, when it happens to be a cold wind that produces the effect, because when you most want your fire, you are sometimes obliged to extinguish it. To understand this, it may be considered that the rising light air, to obtain a free issue from the funnel, must push out of its way or oblige the air that is over it to rise. In a time of calm or of little wind this is done visibly, for we see the smoke that is brought up by that air rise in a column above the chimney. But when a violent current of air, that is, a

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strong

* See Appendix, N^o II.

strong wind, passes over the top of a chimney, its particles have received so much force, which keeps them in a horizontal direction and follow each other so rapidly, that the rising light air has not strength sufficient to oblige them to quit that direction and move upwards to permit its issue. Add to this, that some of the current passing over that side of the funnel which it first meets with, viz. at A, having been compressed by the resistance of the funnel, may expand itself over the flue, and strike the interior opposite side at B, from whence it may be reflected downwards and from side to side in the direction of the pricked lines c c c.

Plate I.
Figure 5.

Remedies. In some places, particularly in Venice, where they have not stacks of chimneys but single flues, the custom is, to open or widen the top of the flue rounding in the true form of a funnel; which some think may prevent the effect just mentioned, for that the wind blowing over one of the edges into the funnel may be slanted out again on the other side by its form. I have had no experience of this; but I have lived in a windy country, where the contrary is practised, the tops of the flues being *narrowed* inwards, so as to form a slit for the issue of the smoke, long as the breadth of the funnel, and only four inches wide. This seems to have been contrived on a supposition that the entry of the wind would thereby be obstructed, and perhaps it might have been imagined, that the whole force of the rising warm air being condensed, as it were, in the narrow opening, would thereby be strengthened, so as to overcome the resistance of the wind. This however did not always succeed; for when the wind was at north-east and blew fresh, the smoke was forced down by fits into the room I commonly sat in, so as to oblige me to shift the fire into another. The position of the slit of this funnel was indeed north-east and south-west. Perhaps if it had lain across the wind, the effect might have been different. But on this I can give no certainty.

Plate I.
Figure 6.

tainty. It seems a matter proper to be referred to experiment. Possibly a turn-cap might have been serviceable, but it was not tried.

Chimneys have not been long in use in England. I formerly saw a book printed in the time of queen Elizabeth, which remarked the then modern improvements of living, and mentioned among others the convenience of chimneys. "Our forefathers," said the author, "had no chimneys. There was in each dwelling house only one place for a fire, and the smoke went out through a hole in the roof; but now there is scarce a gentleman's house in England that has not at least one chimney in it."—When there was but one chimney, its top might then be opened as a funnel, and perhaps, borrowing the form from the Venetians, it was then the flue of a chimney got that name. Such is now the growth of luxury, that in both England and France we must have a chimney for every room, and in some houses every possessor of a chamber, and almost every servant, will have a fire; so that the flues being necessarily built in stacks, the opening of each as a funnel is impracticable. This change of manners soon consumed the firewood of England, and will soon render fuel extremely scarce and dear in France, if the use of coals be not introduced in the latter, kingdom as it has been in the former, where it at first met with opposition; for there is extant in the records of one of queen Elizabeth's parliaments, a motion made by a member, reciting, "that many dyers, brewers, smiths, and other artificers of London, had of late taken to the use of pitcoal for their fires, instead of wood, which filled the air with noxious vapours and smoke, very prejudicial to the health, particularly of persons coming out of the country; and therefore moving that a law might pass to prohibit the use of such fuel (at least during the session of parliament) by those artificers."—It seems it was not then commonly used in private houses. Its supposed unwholesomeness

was an objection. Luckily the inhabitants of London have got over that objection, and now think it rather contributes to render their air salubrious, as they have had no general pestilential disorder since the general use of coals, when, before it, such were frequent. Paris still burns wood at an enormous expence continually augmenting, the inhabitants having still that prejudice to overcome. In Germany you are happy in the use of stoves, which save fuel wonderfully : Your people are very ingenious in the management of fire ; but they may still learn something in that art from the Chinese*, whose country being greatly populous and fully cultivated, has little room left for the growth of wood, and having not much other fuel that is good, have been forced upon many inventions during a course of ages, for making a little fire go as far as possible.

I have thus gone through all the common causes of the smoking of chimneys that I can at present recollect as having fallen under my observation ; communicating the remedies that I have known successfully used for the different cases, together with the principles on which both the disease and the remedy depend, and confessing my ignorance wherever I have been sensible of it. You will do well, if you publish, as you propose, this letter, to add in notes, or as you please, such observations as may have occurred to your attentive mind ; and if other philosophers will do the same, this part of science, though humble, yet of great utility, may in time be perfected. For many years past, I have rarely met with a case of a smoky chimney, which has not been solvable on these principles, and cured by these remedies, where people have been willing to apply them ; which is indeed not always the case ; for many have prejudices in favour of the nostrums of pretending chimney-doctors and fumists, and some have conceits and fancies of their own, which they rather chuse to try, than to lengthen a funnel, alter the size of an opening, or admit air into a room, however necessary ; for some are as
much

* See Appendix, N^o III.

much afraid of fresh air as persons in the hydrophobia are of fresh water. I myself had formerly this prejudice, this *aerophobia*, as I now account it, and dreading the supposed dangerous effects of cool air, I considered it as an enemy, and closed with extreme care every crevice in the rooms I inhabited. Experience has convinced me of my error. I now look upon fresh air as a friend: I even sleep with an open window. I am persuaded that no common air from without, is so unwholesome as the air within a close room that has been often breathed and not changed. Moist air too, which formerly I thought pernicious, gives me now no apprehensions: For considering that no dampness of air applied to the outside of my skin, can be equal to what is applied to and touches it within, my whole body being full of moisture, and finding that I can lie two hours in a bath twice a week, covered with water, which certainly is much damper than any air can be, and this for years together, without catching cold, or being in any other manner disordered by it, I no longer dread mere moisture, either in air or in sheets or shirts: And I find it of importance to the happiness of life, the being freed from vain terrors, especially of objects that we are every day exposed inevitably to meet with. You physicians have of late happily discovered, after a contrary opinion had prevailed some ages, that fresh and cool air does good to persons in the small pox and other fevers. It is to be hoped that in another century or two we may all find out, that it is not bad even for people in health. And as to moist air, here I am at this present writing in a ship with above forty persons, who have had no other but moist air to breathe for six weeks past; every thing we touch is damp, and nothing dries, yet we are all as healthy as we should be on the mountains of Switzerland, whose inhabitants are not more so than those of Bermuda or St. Helena, islands on whose rocks the waves are dashed into millions of particles, which fill the air with damp, but produce no diseases

cases, the moisture being pure, unmixed with the poisonous vapours arising from putrid marshes and stagnant pools, in which many insects die and corrupt the water. These places only, in my opinion, (which however I submit to yours) afford unwholesome air; and that it is not the mere water contained in damp air, but the volatile particles of corrupted animal matter mixed with that water, which renders such air pernicious to those who breathe it. And I imagine it a cause of the same kind that renders the air in close rooms, where the perspirable matter is breathed over and over again by a number of assembled people, so hurtful to health. After being in such a situation, many find themselves affected by that *febricula*, which the English alone call *a cold*, and, perhaps from the name, imagine that they caught the malady by *going out* of the room, when it was in fact by being in it.

You begin to think that I wander from my subject, and go out of my depth. So I return again to my chimneys.

We have of late many lecturers in experimental philosophy. I have wished that some of them would study this branch of that science, and give experiments in it as a part of their lectures. The addition to their present apparatus need not be very expensive. A number of little representations of rooms composed each of five panes of sash glass, framed in wood at the corners, with proportionable doors, and moveable glass chimneys, with openings of different sizes, and different lengths of funnel, and some of the rooms so contrived as to communicate on occasion with others, so as to form different combinations, and exemplify different cases; with quantities of green wax taper cut into pieces of an inch and half, sixteen of which stuck together in a square, and lit, would make a strong fire for a little glass chimney, and blown out would continue to burn and give smoke as long as desired. With such an apparatus all the operations of smoke and rarefied air in rooms and chimneys might be seen through their transparent

rent sides; and the effect of winds on chimneys, commanded or otherwise, might be shown by letting the entering air blow upon them through an opened window of the lecturer's chamber, where it would be constant while he kept a good fire in his chimney. By the help of such lectures our fumists would become better instructed. At present they have generally but one remedy, which perhaps they have known effectual in some one case of smoky chimneys, and they apply that indiscriminately to all the other cases, without success,—but not without expence to their employers.

With all the science, however, that a man shall suppose himself possessed of in this article, he may sometimes meet with cases that shall puzzle him. I once lodged in a house at London, which, in a little room, had a single chimney and funnel. The opening was very small, yet it did not keep in the smoke, and all attempts to have a fire in this room were fruitless. I could not imagine the reason, till at length observing that the chamber over it, which had no fire-place in it, was always filled with smoke when a fire was kindled below, and that the smoke came through the cracks and crevices of the wainscot; I had the wainscot taken down, and discovered that the funnel which went up behind it, had a crack many feet in length, and wide enough to admit my arm, a breach very dangerous with regard to fire, and occasioned probably by an apparent irregular settling of one side of the house. The air entering this breach freely, destroyed the drawing force of the funnel. The remedy would have been, filling up the breach or rather rebuilding the funnel: But the landlord rather chose to stop up the chimney.

Another puzzling case I met with at a friend's country house near London. His best room had a chimney in which, he told me, he never could have a fire, for all the smoke came out into the room. I flattered myself I could easily find the cause, and prescribe the cure. I had a fire
made

made there, and found it as he said. I opened the door, and perceived it was not want of air. I made a temporary contraction of the opening of the chimney, and found that it was not its being too large that caused the smoke to issue. I went out and looked up at the top of the chimney: Its funnel was joined in the same stack with others, some of them shorter, that drew very well, and I saw nothing to prevent its doing the same. In fine, after every other examination I could think of, I was obliged to own the insufficiency of my skill. But my friend, who made no pretension to such kind of knowledge, afterwards discovered the cause himself. He got to the top of the funnel by a ladder, and looking down, found it filled with twigs and straw cemented by earth, and lined with feathers. It seems the house, after being built, had stood empty some years before he occupied it; and he concluded that some large birds had taken the advantage of its retired situation to make their nest there. The rubbish, considerable in quantity, being removed, and the funnel cleared, the chimney drew well, and gave satisfaction.

In general, smoke is a very tractable thing, easily governed and directed when one knows the principles. and is well informed of the circumstances. You know I made it *descend* in my Pennsylvania stove. I formerly had a more simple construction, in which the same effect was produced, but visible to the eye. It was composed

Plate I.
Figure 7.

of two plates A B and C D, placed as in the figure. The lower plate A B rested with its edge in the angle made by the hearth with the back of the chimney. The upper plate was fixed to the breast, and lapt over the lower about six inches, leaving a space of four inches wide and the length of the plates (near two feet) between them. Every other passage of air into the funnel was well stopped. When therefore a fire was made at E, for the first time with charcoal, till the air in the funnel was a little heated through the plates, and then
wood

wood laid on, the smoke would rise to A, turn over the edge of that plate, descend to D, then turn under the edge of the upper plate, and go up the chimney. It was pretty to see, but of no great use. Placing therefore the under plate in a higher situation, I removed the upper plate C D, and placed it perpendicularly, so that the upper edge of the lower plate A B came within about three inches of it, and might be pushed farther from it, or suffered to come nearer to it by a moveable wedge between them. The flame then ascending from the fire at E, was carried to strike the upper plate, made it very hot, and its heat rose and spread with the rarefied air into the room.

Plate I.
Figure 8.

I believe you have seen in use with me, the contrivance of a sliding-plate over the fire, seemingly placed to oppose the rising of the smoke, leaving but a small passage for it, between the edge of the plate and the back of the chimney. It is particularly described, and its uses explained, in my former printed letter, and I mention it here only as another instance of the tractability of smoke*.

What is called the Staffordshire chimney, affords an example of the same kind. The opening of the chimney is bricked up, even with the fore-edge of its jams, leaving open only a passage over the grate of the same width, and perhaps eight inches high. The grate consists of semicircular bars, their upper bar of the greatest diameter, the others under it smaller and smaller, so that it has the appearance of half a round basket. It is, with the coals it contains, wholly without the wall that shuts up the chimney, yet the smoke bends and enters the passage above it, the draft being strong, because no air can enter that is not obliged to pass near or through the fire, so that all that the funnel is filled with is much heated, and of course much rarefied.

D

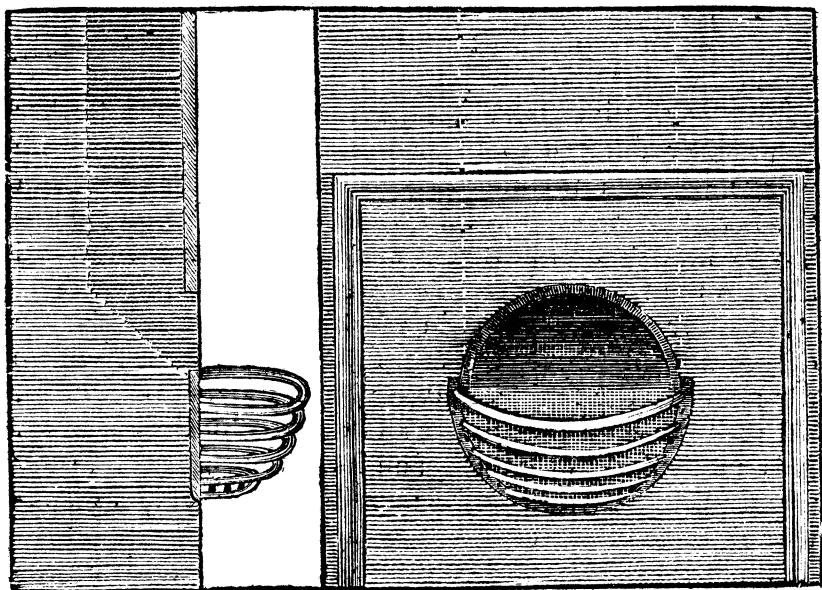
Much

* See Appendix, N^o II.

STAFFORDSHIRE FIRE-PLACE.

SIDE VIEW.

FRONT VIEW.



Much more of the prosperity of a winter country depends on the plenty and cheapness of fuel, than is generally imagined. In travelling I have observed, that in those parts where the inhabitants can have neither wood nor coal nor turff but at excessive prices, the working people live in miserable hovels, are ragged, and have nothing comfortable about them. But where fuel is cheap, (or where they have the art of managing it to advantage) they are well furnished with necessaries, and have decent habitations. The obvious reason is, that the working hours of such people are the profitable hours, and they who cannot afford sufficient fuel have fewer such hours in the twenty four, than those who have it cheap and plenty : For much of the domestic work of poor women, such as spinning,

spinning, sewing, knitting ; and of the men in those manufactures that require little bodily exercise, cannot well be performed where the fingers are numbed with cold : Those people, therefore, in cold weather, are induced to go to bed sooner, and lie longer in a morning, than they would do if they could have good fires or warm stoves to sit by ; and their hours of work are not sufficient to produce the means of comfortable subsistence. Those public works, therefore, such as roads, canals, &c. by which fuel may be brought cheap into such countries from distant places, are of great utility ; and those who promote them may be reckoned among the benefactors of mankind.

I have great pleasure in having thus complied with your request, and in the reflection that the friendship you honour me with, and in which I have ever been so happy, has continued so many years without the smallest interruption. Our distance from each other is now augmented, and nature must soon put an end to the possibility of my continuing our correspondence : But if consciousness and memory remain in a future state, my esteem and respect for you, my dear friend, will be everlasting.

B. F.

A P P E N D I X.

NOTES FOR THE LETTER UPON CHIMNEYS.

N^o I.

THE latest work on architecture that I have seen, is that entitled NUTSHELLS, which appears to be written by a very ingenious man, and contains a table of the proportions of the openings of chimneys; but they relate solely to the proportions he gives his rooms, without the smallest regard to the funnels. And he remarks, respecting those proportions, that they are similar to the harmonic divisions of a monochord*. He does not indeed lay much stress on this; but it shows that we like the appearance of principles; and where we have not true ones, we have some satisfaction in producing such as are imaginary.

N^o II.

THE description of the sliding plates here promised, and which hath been since brought into use under various names, with some immaterial changes, is contained in a former letter to J. B. Esq. as follows:

To J. B. Esq. at Boston, in New-England.

Dear Sir,

London, Dec. 2, 1758.

I HAVE executed here an easy simple contrivance, that I have long since had in speculation, for keeping rooms warmer

* "It may be just remarked here, that upon comparing these proportions with those arising from the common divisions of the monochord, it happens that the first answers to unison, and although the second is a discord, the third answers to the third minor, the fourth to the third major, the fifth to the fourth, the sixth to the fifth, and the seventh to the octave." NUTSHELLS, page 85.

warmer in cold weather than they generally are, and with less fire. It is this. The opening of the chimney is contracted, by brick-work faced with marble slabs, to about two feet between the jams, and the breast brought down to within about three feet of the hearth.—An iron frame is placed just under the breast, and extending quite to the back of the chimney, so that a plate of the same metal may slide horizontally backwards and forwards in the grooves on each side of the frame. This plate is just so large as to fill the whole space, and shut the chimney entirely when thrust quite in, which is convenient when there is no fire. Drawing it out, so as to leave a space between its further edge and the back, of about two inches; this space is sufficient for the smoke to pass; and so large a part of the funnel being stopt by the rest of the plate, the passage of warm air out of the room, up the chimney, is obstructed and retarded, and by that means much cold air is prevented from coming in through crevices, to supply its place. This effect is made manifest three ways. First, when the fire burns briskly in cold weather, the howling or whistling noise made by the wind, as it enters the room through the crevices, when the chimney is open as usual, ceases as soon as the plate is slid in to its proper distance. Secondly, opening the door of the room about half an inch, and holding your hand against the opening, near the top of the door, you feel the cold air coming in against your hand, but weakly, if the plate be in. Let another person suddenly draw it out, so as to let the air of the room go up the chimney, with its usual freedom where chimneys are open, and you immediately feel the cold air rushing in strongly. Thirdly, if something be set against the door, just sufficient, when the plate is in, to keep the door nearly shut, by resisting the pressure of the air that would force it open: Then, when the plate is drawn out, the door will be forced open by the increased pressure of the outward cold air endeavouring to get in to supply the place of the
warm

warm air, that now passes out of the room to go up the chimney. In our common open chimneys, half the fuel is wasted, and its effect lost; the air it has warmed being immediately drawn off. Several of my acquaintance having seen this simple machine in my room, have imitated it at their own houses, and it seems likely to become pretty common. I describe it thus particularly to you, because I think it would be useful in *Boston*, where firing is often dear.

Mentioning chimneys puts me in mind of a property I formerly had occasion to observe in them, which I have not found taken notice of by others; it is, that in the summer time, when no fire is made in the chimneys, there is, nevertheless, a regular draft of air through them; continually passing upwards, from about five or six o'clock in the afternoon, till eight or nine o'clock the next morning, when the current begins to slacken and hesitate a little, for about half an hour, and then sets as strongly down again, which it continues to do till towards five in the afternoon, then slackens and hesitates as before, going sometimes a little up, then a little down, till in about a half an hour it gets into a steady upward current for the night, which continues till eight or nine the next day; the hours varying a little as the days lengthen and shorten, and sometimes varying from sudden changes in the weather; as if, after being long warm, it should begin to grow cool about noon, while the air was coming down the chimney, the current will then change earlier than the usual hour, &c.

This property in chimneys I imagine we might turn to some account, and render improper, for the future, the old saying, *as useless as a chimney in summer*. If the opening of the chimney, from the breast down to the hearth, be closed by a slight moveable frame or two, in the manner of doors, covered with canvas, that will let the air through, but keep out the flies; and another little frame set within upon the hearth, with hooks on which to hang joints of meat, fowls, &c. wrapt well in wet linen cloths, three or
four

four fold, I am confident that if the linen is kept wet, by sprinkling it once a day, the meat would be so cooled by the evaporation, carried on continually by means of the passing air, that it would keep a week or more in the hottest weather. Butter and milk might likewise be kept cool, in vessels or bottles covered with wet cloths. A shallow tray, or keeler, should be under the frame to receive any water that might drip from the wetted cloths. I think, too, that this property of chimneys might, by means of smoke-jack vanes, be applied to some mechanical purposes, where a small but pretty constant power only is wanted.

If you would have my opinion of the cause of this changing current of air in chimneys, it is, in short, as follows. In summer time there is generally a great difference in the warmth of the air at mid-day and midnight, and, of course, a difference of specific gravity in the air, as the more it is warmed the more it is rarefied. The funnel of a chimney being for the most part surrounded by the house, is protected, in a great measure, from the direct action of the sun's rays, and also from the coldness of the night air. It thence preserves a middle temperature between the heat of the day, and the coldness of the night. This middle temperature it communicates to the air contained in it. If the state of the outward air be cooler than that in the funnel of the chimney, it will, by being heavier, force it to rise, and go out at the top. What supplies its place from below, being warmed, in its turn, by the warmer funnel, is likewise forced up by the colder and weightier air below, and so the current is continued till the next day, when the sun gradually changes the state of the outward air, makes it first as warm as the funnel of the chimney can make it, (when the current begins to hesitate) and afterwards warmer. Then the funnel being cooler than the air that comes into it, cools that air, makes it heavier than the outward air, of course it descends; and what succeeds it from above, being cooled in its turn, the descending current continues

tinues till towards evening, when it again hesitates and changes its course, from the change of warmth in the outward air, and the nearly remaining same middle temperature in the funnel.

Upon this principle, if a house were built behind *Beacon-hill*, an adit carried from one of the doors into the hill horizontally, till it met with a perpendicular shaft sunk from its top, it seems probable to me, that those who lived in the house, would constantly, in the heat even of the calmest day, have as much cool air passing through the house, as they should chuse; and the same, though reversed in its current, during the stillest night.

I think, too, this property might be made of use to miners; as where several shafts or pits are sunk perpendicularly into the earth, communicating at bottom by horizontal passages, which is a common case, if a chimney of thirty or forty feet high were built over one of the shafts, or so near the shaft, that the chimney might communicate with the top of the shaft, all air being excluded but what should pass up or down by the shaft, a constant change of air would, by this means, be produced in the passages below, tending to secure the workmen from those damps which so frequently incommode them. For the fresh air would be almost always going down the open shaft, to go up the chimney, or down the chimney to go up the shaft. Let me add one observation more, which is, that if that part of the funnel of a chimney, which appears above the roof of a house, be pretty long, and have three of its sides exposed to the heat of the sun successively, viz. when he is in the east, in the south, and in the west, while the north side is sheltered by the building from the cool northerly winds; such a chimney will often be so heated by the sun, as to continue the draft strongly upwards, through the whole twenty four hours, and often for many days together. If the outside of such a chimney be painted black, the effect will be still greater, and the current stronger.

N° III.

IT is said the northern Chinese have a method of warming their ground floors, which is ingenious. Those floors are made of tile a foot square and two inches thick, their corners being supported by bricks set on end, that are a foot long and four inches square, the tiles, too, join into each other, by ridges and hollows along their sides. This forms a hollow under the whole floor, which on one side of the house has an opening into the air, where a fire is made, and it has a funnel rising from the other side to carry off the smoke. The fuel is a sulphurous pitcoal, the smell of which in the room is thus avoided, while the floor and of course the room is well warmed. But as the underside of the floor must grow foul with soot, and a thick coat of soot prevents much of the direct application of the hot air to the tiles, I conceive that burning the smoke by obliging it to descend through red coals, would in this construction be very advantageous, as more heat would be given by the flame than by the smoke, and the floor being thereby kept free from soot would be more heated with less fire. For this purpose I would propose erecting the funnel close to the grate, so as to have only an iron plate between the fire and the funnel, through which plate the air in the funnel being heated, it will be sure to draw well, and force the smoke to descend, as in the figure

Plate I.
Figure 9.

where A is the funnel or chimney, B the grate on which the fire is placed, C one of the apertures through which the descending smoke is drawn into the channel D of figure 10, along which channel it is conveyed by a circuitous rout, as designated by the arrows, until it arrives at the small aperture E, figure 10, through which it enters the funnel F. G in both figures is the iron plate against which the fire is made, which being heated thereby, will rarefy the air in that part of the funnel, and cause the smoke to ascend rapidly. The flame thus dividing

E

from

from the grate to the right and left, and turning in passages disposed, as in figure 13, so as that every part of the floor may be visited by it before it enters the funnel F, by the two passages E E, very little of the heat will be lost, and a winter room thus rendered very comfortable.

N° IV.

PAGE 8. *Few can imagine, &c.* It is said the Icelanders have very little fuel, chiefly drift wood that comes upon their coast. To receive more advantage from its heat, they make their doors low, and have a stage round the room above the door, like a gallery, wherein the women can sit and work, the men read or write, &c. The roof being tight, the warm air is confined by it and kept from rising higher and escaping; and the cold air which enters the house when the door is opened, cannot rise above the level of the top of the door, because it is heavier than the warm air above the door, and so those in the gallery are not incommoded by it. Some of our too lofty rooms might have a stage so constructed as to make a temporary gallery above, for the winter, to be taken away in summer. Sedentary people would find much comfort there in cold weather.

N° V.

PAGE 26. *Where they have the art of managing it, &c.*

In some houses of the lower people among the northern nations of Europe, and among the poorer sort of Germans in Pennsylvania, I have observed this construction, which appears very advantageous. A is the kitchen with its chimney; B an iron stove in the stove-room. In a corner of the chimney is a hole through the back into the stove, to put in fuel, and another hole above it to let the smoke of the stove come back into the chimney. As soon as the cooking is over, the brands in the kitchen chimney are put

Plate I.
Figure II.

put through the hole to supply the stove, so that there is seldom more than one fire burning at a time. In the floor over the stove-room, is a small trap door, to let the warm air rise occasionally into the chamber. Thus the whole house is warmed at little expence of wood, and the stove-room kept constantly warm; so that in the coldest winter nights, they can work late, and find the room still comfortable when they rise to work early. An English farmer in America who makes great fires in large open chimneys, needs the constant employment of one man to cut and haul wood for supplying them; and the draft of cold air to them is so strong, that the heels of his family are frozen while they are scorching their faces, and the room is never warm, so that little sedentary work can be done by them in winter. The difference in this article alone of œconomy, shall, in a course of years, enable the German to buy out the Englishman, and take possession of his plantation.

MISCELLANEOUS OBSERVATIONS.

CHIMNEYS whose funnels go up in the north wall of a house and are exposed to the north winds, are not so apt to draw well as those in a south wall; because when rendered cold by those winds, they draw downwards.

Chimneys enclosed in the body of a house are better than those whose funnels are exposed in cold walls.

Chimneys in stacks are apt to draw better than separate funnels, because the funnels that have constant fires in them, warm the others in some degree that have none.

One of the funnels in a house I once occupied, had a particular funnel joined to the south side of the stack, so that three of its sides were exposed to the sun in the course of the day, viz. the east side E during the morning, the south side S in the middle part of the day, and the west side W during the afternoon, while its north side was sheltered

Plate I.
Figure 12.

ed by the stack from the cold winds. This funnel, which came from the ground floor, and had a considerable height above the roof, was constantly in a strong drawing state day and night, winter and summer.

Blackening of funnels exposed to the sun, would probably make them draw still stronger.

In Paris I saw a fire-place so ingeniously contrived as to serve conveniently two rooms, a bedchamber and a study. The funnel over the fire was round. The fire-place was

Plate I.
Figure 13.

of cast iron, having an upright back A, and two horizontal semicircular plates B C, the whole so ordered as to turn on the pivots D E. The plate B always stopped that part of the round funnel that was next to the room without fire, while the other half of the funnel over the fire was always open. By this means a servant in the morning could make a fire on the hearth C, then in the study, without disturbing the master by going into his chamber; and the master when he rose, could with a touch of his foot turn the chimney on its pivots, and bring the fire into his chamber, keep it there as long as he wanted it, and turn it again when he went out into his study. The room which had no fire in it, was also warmed by the heat coming through the back plate, and spreading in the room as it could not go up the chimney.

Explanation

